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AN AIRPOWER APPLICATION FRAMEWORK:
MODELING COERCIVE AIRPOWER STRATEGIES

BY
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The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

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Lieutenant Colonel Anthony M. Weigand was commissioned through the United States Air Force Academy in 1982. Following graduation, he was assigned to Rome Air Development Center to develop optical communications systems for fielded forces. Subsequent to this, he worked national warning system integration issues at Air Force Space Command and space system development at Space and Missile Systems Center. In Lieutenant Colonel Weigand's most recent assignments, he was Air Force Materiel Command's Congressional Liaison and Aide to its commander. Lieutenant Colonel Weigand holds a bachelor's degree in Electrical Engineering from the Air Force Academy, a master's degree in Electrical Engineering from Syracuse University, and a master's of business administration from Wright State University. In July 1998, he was assigned to Air Education and Training Command as a strategic planner.

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Most importantly, I want to express my sincere love and appreciation to my wife, Susanne, and daughter, Kellen, for their patience and understanding during those many times when I put the completion of this study ahead of much more important interests.

Abstract

This study focuses on the development of a theoretical framework for the application of coercive airpower strategies that can be used in the construction of a decision aid for use by airpower strategists. The author begins this work by synthesizing the theoretical concepts of several strategic airpower analysts. The result of this synthesis is an Airpower Application Framework (AAF), which provides a guide for understanding and evaluating the coercive mechanisms that tie the *ends* of policy to the *means* of military force. The author then undertakes a review of on-going modeling and simulation efforts within the Air Force and assesses their use within the AAF. He notes a shortcoming in techniques for strategic policy analysis and introduces the concept of exploratory modeling as a possible remedy. After discussing the difficulties inherent in modeling complex, human-driven activities, the author concludes with a brief review of the implications of foregoing the implementation of decision aids such as the AAF.

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Chapter 1

Introduction

It is a common observation, and a true one, that practical qualities in a soldier are more important than a knowledge of theory. But this truth has often been made the excuse for indolence and indifference, which except in rare and gifted individuals, destroys practical efficiency. It is also true that, other things being equal, the officer who keeps his mind alert by intelligent exercise, and who systematically studies the reasons of actions and the materials and conditions and difficulties with which he may have to deal, will be the stronger practical man and the better soldier.

Eliha Root, 1903

The new millenium finds the armed forces of the United States in a situation of geopolitical instability, mission creep, and budgetary decline. The relative stability of the cold war has been usurped by the multipolar exigencies of a new world. The Soviet Union, a once faithful adversary, has been replaced by a host of situation-dependant alliances and inconstant loyalties hastily assembled to thwart international bullies. While the glow of victory in Desert Storm has dimmed amid growing factional hostility and violence, the US continues to act as world policeman. Humanitarian and peace-keeping operations consume more and more resources as operation-tempos surge. Terrorism, an ever present yet ill-defined threat, grows. At home, budgetary realities and fiscal constraints increase inter-service rivalry over roles, missions, and resources while forcing painful reductions in personnel, weapon systems, and infrastructure. And, amidst this clamor, the Information Age with its myriad implications is dawning.

Some argue the Information Age heralds a new era in the conduct of all types of warfare.¹ Instantaneous global communications, worldwide real-time reconnaissance, and advanced modeling and simulation capabilities promise tremendous efficiency, effectiveness, and flexibility in the conduct of military operations. As Harry Summers, a fellow of the Army War College, puts it, the objective of these technologies will be to “add infinite complexity to the opponent’s situation while collapsing his ability to act.”² Unfortunately, the effective use of these technologies does not come without significant effort. In order to realize Summers’ goal of collapsing an adversary’s ability to act, the US must thoroughly understand this adversary, the constraints inherent in the situation, and the capabilities and limitations of its forces. It is in gaining this understanding that modeling and simulation has the potential to be an invaluable tool for military and political leaders and analysts.

The field of modeling and simulation encompasses a broad spectrum of activities, which range from describing the behavior of an individual component, to assessing the behavior of an entire system, to providing education and training for the conduct of complex operations. At the most basic level, models and simulations allow humans to interact with artificial representations of reality. In military applications, modeling and simulation (M&S) has become essential not only to the conduct of operations, but also to the evaluation of force structure and the procurement of weapon systems. Indeed, critical military assessments such as the Quadrennial Defense Review, are highly impacted by threat analyses, service capability assessments, and engagement options as depicted in a variety of models and simulations. Such is the importance, impact, and pervasiveness of M&S that the

¹ Maggie Belknap, “The Force-On-Force Model: An Anachronism in the Information Age,” *Joint Forces Quarterly*, Spring 1997, 116.

² Harry Summers, “Modern Science Can’t Make a Soldier,” National Weekly Edition of The Washington Times, 8 February 1998, p34.

Department of Defense and component services have established organizations chartered to coordinate the many diverse activities in this area. Indeed, these organizations are enabling the development of highly integrated M&S systems designed to educate and train operations and support personnel at the tactical, operational, and strategic levels as well as analyze the weapon systems and infrastructure required across the spectrum of conflict. To do so effectively, these integrated systems must encompass models and simulations of a wide variety of threats, physical environments, individual system components, weapon systems, tactical engagements, campaigns, support requirements, and system level and strategic effects. While many of these areas are, to a greater or lesser extent, being addressed by the Air Force's M&S efforts, perhaps the most critical area of all—the modeling and simulation of strategic effects—is lagging. Paradoxically, it is the ability to understand and exploit these effects that most directly impacts America's ability to coerce an adversary.

The purpose of this study is to develop a conceptual model for use in the strategic application of coercive airpower and as the basis to assist the M&S process. As such, this work does not explore many areas in which M&S is having a dramatic impact in helping decide which systems are procured, employed, and supported. Nor does it deal with the advances being made in the training arena. Instead, it focuses on the development of a theoretical framework for modeling strategic effects and assesses current M&S concepts and techniques that portray the effects of applied military force.

The development of a theoretical construct for applying airpower is necessary for a reasoned assessment of M&S efforts. However, this area of study is fraught with complexity and disagreement. Airpower advocates and critics are locked in an on-going debate on the proper application of airpower and the effects of its use. Chapter Two of this work will attempt to synthesize the concepts of several theorists into an

airpower application framework, which can be used to assess, and possibly guide, M&S efforts. The theoretical point of departure for this framework is the work of John Warden. From his model of the enemy as a system, the airpower application framework gains substance and theoretical underpinnings from the work of Robert Pape, Karl Mueller, and Thomas Ehrhard. Here the focus is on developing a model that incorporates the substantive work of these theorists into a coherent product.

A salient point in this development is the type of use for which the model is designed. The airpower application framework provides the necessary structure for developing a decision aid. The very nature of the system under consideration precludes the development of any type of deterministic or predictive model capable of providing a “right” answer to a policy question. At best, this construct might aid the airpower strategist or policy analyst in fashioning a rational approach to the application of airpower that is supported by substantive argument and historical precedent.

War is the most complex of human endeavors. While some might debate this, there is no doubt that modern warfare is an enormously complex undertaking that is subject to myriad factors both on and off the battlefield. The airpower application framework reflects these complexities. Its use must be tempered by an understanding of the strategies that link desired outcomes to force application. In addition, serious consideration must be given to the nature of the conflict, the coercive mechanisms that connect *ends* and *means*, the historical evidence that supports the theory, and system-level targeting effects. Chapter Three provides a brief discussion of these factors and their impact.

Turning from the development of the analysis framework, Chapter Four provides a discussion of past and present modeling and simulation efforts. The chapter briefly reviews wargaming, the forefather of current

M&S initiatives, and an important contributor in all areas of military science. The discussion moves to a review of on-going M&S efforts and the structures created within the Department of Defense to manage them. Included in this discussion is an assessment of each effort's place within an airpower application framework. The chapter concludes with a discussion of the use of exploratory modeling as a method of assessing coercive airpower strategies.

Chapter Five reviews several issues that must be addressed in the development and implementation of this application framework. These issues range from criticisms of size and complexity, to the difficulties of validating model outputs and the need for a cadre of M&S professionals. Finally, Chapter Six highlights the significant impact of modeling and simulation from the perspective of a global wargame. The study concludes with a discussion of the implications of the airpower application framework and the requirement for this tool in the air strategist's kit.

Chapter 2

The Airpower Application Framework

When you pick up one piece of this planet, you find that, one way or another, it's attached to everything else—if you jiggle over here, something is going to wiggle over there... We need this sense of the continuing interconnectedness of the system as part of the common knowledge...

*Wallace White, "Profiles (Sylvia Earle)"
in The New Yorker*

In dealing with the theoretical foundations for the effective use of airpower, one must begin with an appreciation of the complexity of the task. While the idea of a pilot climbing into a cockpit, flying over enemy territory, choosing a target, and dropping a bomb is straightforward, it belies a host of complex and interconnected relationships from the highest levels of international diplomacy, to the intricacies of military strategy, to the daily routines of aircraft maintenance. Each of these activities constitutes an important factor in the many systems and subsystems from which they are drawn. The idea that any of these factors may have a major impact on the outcome of a system lies at the heart of systems theory and its application to airpower employment.

Systems theory reveals that systems in general are highly complex and contingent, yet display surprising regularity.³ Kenneth Waltz noted this characteristic in his observation that states, despite often vast differences in capability, function in much the same way within the

³ Robert Jervis, *System Effects: Complexity In Political And Social Life* (Princeton, New Jersey: Princeton University Press, 1997), 4.

constraints of the international system⁴ — a salient point in the development of airpower employment theories. Systems are characterized as being composed of a set of interconnected elements in which a change to one element produces changes in others and in which “the entire system exhibits properties and behaviors that are different from those of the parts.”⁵ This type of relationship often results in non-linear behaviors and unintended results, which makes prediction of system-level effects highly problematic. Nonetheless, it is necessary to pursue an investigation of these effects in order to develop an airpower application framework. Colonel John Warden’s system model, while inadequate in some respects, serves as a useful starting point for this investigation.

Airpower Theorists

Colonel Warden won fame as the originator of the Desert Storm air campaign by approaching the problem from a strategic rather than tactical perspective. His concern was to destroy the enemy as a system rather than the destruction of a collection of individual targets. His premise was the need to “focus on the totality of our enemy, then on our objectives, and next on what must happen to the enemy before our objectives become his objectives.”⁶ At the strategic level, Warden proposed obtaining the US political objectives by “causing such changes to one or more parts of the enemy’s physical system that the enemy decides to adopt our objectives, or we make it physically impossible for him to oppose us.”⁷ Central to this view was the Clausewitzian concept of a center of gravity (COG). Defined by Clausewitz as the “hub of all power

⁴ Kenneth Waltz, *Theory of International Politics* (Reading, Mass.: Addison-Wesley, 1979): 96.

⁵ Jervis, 6.

⁶ John A. Warden, III, “The Enemy As A System,” *Airpower Journal* 9, no. 1 (Spring 1995): 42.

⁷ *Ibid.*, 43.

and movement”⁸ and by Warden as “that point where the enemy is most vulnerable and...where an attack will have the best chance of being decisive.”⁹ An interrelated set of COGs form the basis of Warden’s five-ring model for airpower employment.

In his analysis, Warden asserts that one could break down any strategic entity¹⁰ into five component parts. The most critical component at the core of the model is leadership. Extending out from this center ring, Warden proposed that organic essentials, infrastructure, population, and fielded forces were the remaining four component rings, arranged in descending order of importance as they relate to the functioning of the system.¹¹

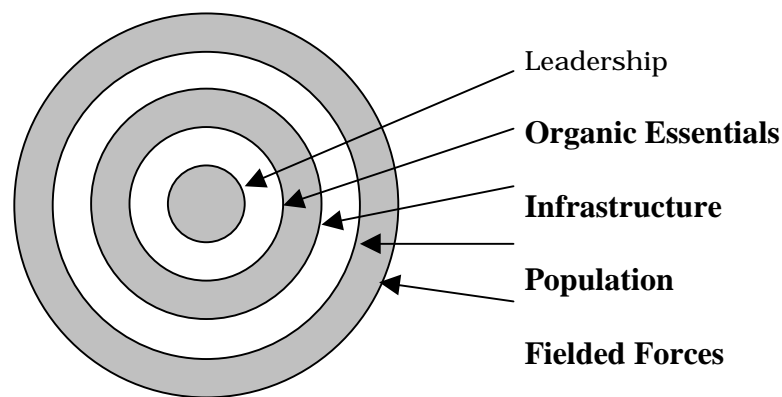


Figure 1. The Enemy as a System
Source: John Warden, “The Enemy As A System”

In this taxonomy, leadership consists of the entity’s command structure: organic essentials, the facilities or processes the entity uses to maintain itself, such as electricity or petroleum; infrastructure, the entity’s

⁸ Carl von Clausewitz, *On War*, ed. and trans. Michael Howard and Peter Paret (Princeton, NJ.: Princeton University Press, 1976): 595.

⁹ John A. Warden, *The Air Campaign: Planning for Combat* (Washington, D.C.: National Defense University Press, 1988): 9.

¹⁰ Warden defined a strategic entity as “anything that can function on its own and is free and able to make decisions as to where it will go and what it will do.” See Warden, “The Enemy As A System”, 45.

¹¹ Warden, “The Enemy As A System”, 42-47.

transportation system; population, the civilian populace; and, fielded forces, the entity's armed forces. Within each of these rings lies one or more COGs upon which the functioning of the ring depends. Warden proposed that each of the rings be continuously subdivided into five sub-rings identical to those just discussed until a true "hub of all power and movement" surfaces.¹² With a relative few of these hubs identified from the expanse of possible targets, the enemy system, Warden theorized, could be disrupted or paralyzed to such an extent by their destruction that victory, and the achievement of political objectives, must necessarily follow. However, it must be noted that Warden is unclear about the particular mechanism underpinning this cause-effect relationship.

Establishing a causal relationship between the application of force and the achievement of a desired political objective is essential to the development of a framework for airpower employment. John Warden ultimately surrendered this linchpin of his theory to "the vaporous metaphor of reducing the enemy's 'energy level of the entire system enough to reach our policy objectives'"¹³ as Dr. Karl Mueller noted in a trenchant review of employment strategies. While some scholars have theorized on this relationship, Robert Pape in *Bombing to Win: Air Power and Coercion in War*¹⁴ develops a model of airpower employment centered on a taxonomy of coercive strategies that adds some of the needed structure for an airpower application framework. Before proceeding with a discussion of these strategies however, a brief discussion of coercive airpower is in order.

¹² For a detailed discussion of Warden and his five-ring model, see David S. Fadok, "John Boyd and John Warden: Airpower's Quest for Strategic Paralysis" in *The Paths of Heaven: The Evolution of Airpower Theory*, ed. Phillip S. Meilinger (Maxwell AFB, Ala.: Air University Press, 1997), 357-398.

¹³ Karl Mueller, "Strategies of Coercion: Denial, Punishment, and the Future of Air Power," School of Advanced Airpower Studies unpublished essay, p. 6, quoting John A. Warden, "Success in Modern War," 173PP.

¹⁴ Robert Pape, *Bombing to Win: Air Power and Coercion in War* (Ithaca: Cornell University Press, 1966).

Coercive airpower “in its most general and basic sense is the use of air power to make an adversary choose to act in a way that it otherwise would (or might) not act.”¹⁵ Used in this manner, the intent of an air attack is not necessarily the destruction of the target, but a desired change in the targeted state’s policies in accordance with the demands of the attacker. Thus, despite what these demands may be, “coercion is an effort to convince the target to concede, not to force it to concede by physically precluding any alternative.”¹⁶ As such, the use of airpower in a coercive mode differs substantially from its use as a brute force method of applying force with the strict intent of destroying a particular target. With this understanding of the nature of airpower and its use as a coercive tool, one can return to Pape’s coercive airpower framework. Brute force uses of airpower are considered later in the chapter.

At the heart of *Bombing to Win* is a theoretical framework for the analysis of coercive air strategies that emphasizes the mechanisms that lead from the application of force to desired political outcomes. Pape describes this means-to-ends chain as:

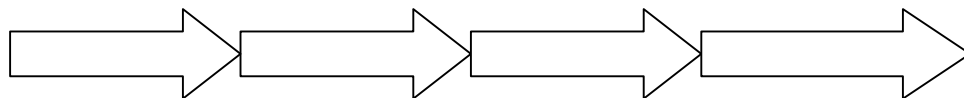


Figure 2. Coercive Airpower Framework
Source: Robert Pape, *Bombing to Win*

Pape’s rationale for describing airpower strategies in this manner is the emphasis it places on the mechanism through which force is translated into political action rather than on the selection of targets. As he describes it “mechanisms provide the intellectual guidance for operational air planners who then translate strategy into actual

¹⁵ Mueller, 3.

¹⁶ Ibid.

campaigns with the forces at their disposal.”¹⁷ Ultimately, Pape describes four categories of coercive air strategies; punishment, risk, denial, and decapitation.

An aerial punishment strategy, according to Pape’s taxonomy, “attempts to inflict enough pain on enemy civilians to overwhelm their territorial interests in a dispute and to cause either the government to concede or the population to revolt against the government.”¹⁸ The mechanisms producing this effect are popular revolt and social disintegration created by the populace’s pain and fear. Pape classifies direct attacks against the enemy population, such as saturation bombing of population centers, and indirect attacks, such as destruction of transportation and power systems, as examples of punishment strategies.

Risk strategies seek to raise the risk to the civilian populace slowly, thus compelling an adversary to concede in order to avoid future costs. Pape most closely associates this strategy with Thomas Schelling who describes this theory in, *Arms and Influence*¹⁹. As with Douhet, “civilian punishment can be inflicted both directly by killing large numbers [of people] and indirectly by destroying economic infrastructure, [thus] depriving the population of essential goods and services.”²⁰ Schelling made the point in this way: “To be coercive, violence has to be anticipated...It is the expectation of more violence that gets the wanted behavior, if the power to hurt can get it at all.”²¹ Risk strategies differ from punishment strategies only in timing, not in the selection of targets

¹⁷ Pape, 56.

¹⁸ Ibid., 59.

¹⁹ Thomas Schelling, *Arms and Influence* (New Haven: Yale University Press, 1966).

²⁰ Pape, 67.

²¹ Schelling, 2-3.

or the mechanisms of the strategies.²² Because of this, Pape generally views risk strategies as a subset of punishment strategies.

Denial strategies seek to render an opponent vulnerable through the destruction of his armed forces, thus making resistance appear futile. While punishment strategies are “intended to alter [an adversary’s] expectations about the costs of victory or defeat,” denial strategies are intended to alter “the adversary’s expectations about the costs of victory.”²³ For this reason, Pape’s denial strategies focus on the destruction of arms manufacturing, interdiction of supplies, disruption of theater-wide movement and communication, and attrition of fielded forces.²⁴ Pape subdivides denial strategies into close air support, strategic interdiction, and operational interdiction. Where strategic interdiction constitutes attacks against military production and transportation facilities, operational interdiction constitutes attacks against tactical supply networks, reinforcements, and command-and-control facilities.²⁵ Pape recognizes three possible outcomes of denial strategies that may lead to substantive coercive effects. These are battlefield breakthroughs, equipment shortages, and operational paralysis brought on by the destruction of supply networks and C² facilities.²⁶

Decapitation, Pape’s fourth coercion strategy, encompasses strikes against key leadership and telecommunication facilities. Pape sees three variants of the decapitation strategy, each involving a slightly different mechanism for fomenting policy change. The first is leadership decapitation, which seeks a cessation of violence by killing specific leaders “on the assumption that they are the driving force behind the

²² Mueller, 9.

²³ Mueller, 8.

²⁴ Pape, 69.

²⁵ Ibid., 69-72.

²⁶ Ibid.

war.”²⁷ The mechanism here is the installation of successors who are not as committed to the war effort or who fear they too will become targets. The second is political decapitation, which attempts to use airpower to create an opportunity for political opposition groups, who are more amenable to concessions, to seize power.²⁸ The mechanisms in this variant are a coup d’etat or popular revolt, either of which may result from airpower’s destruction of the adversary’s internal means of control. The last variant is military decapitation, which attempts to isolate central leadership from its fielded forces through the disruption of national C² networks.²⁹ The mechanism in this final variant is the collapse of fielded forces due to the lack of central direction.

As Mueller observes in his analysis of *Bombing to Win*, this analytical framework holds considerable value for airpower strategists. Mueller however, proposes two modifications to significantly enhance its value in the analysis of airpower employment. “First, the existing categories must be redefined to better reflect the universe of possible strategies...[and] second, in order for the scheme to be adequately comprehensive, it needs to take account of types of strategies that fall between or beyond the bounds of Pape’s categories.”³⁰

The inclusion of denial strategies other than the three variants proposed by Pape is essential to Mueller’s expansion of Pape’s taxonomy. Pape assumes that conflict generally results from territorial disputes, with the result that denial strategies can be reduced to ground support, operational interdiction, and strategic interdiction. ³¹Mueller proposes that “the underlying dynamic of denial...encompasses a variety of other strategic possibilities” including the use of airpower to disrupt an alliance upon which the adversary depends, thus reducing its

²⁷ Ibid., 80.

²⁸ Ibid.

²⁹ Ibid.

³⁰ Mueller, 40.

expectation of success.³² Mueller also proposes air superiority and strategic airlift as two additional denial strategies as exemplified by the Battle of Britain and the Berlin Airlift. Finally, Mueller proposes a gradual denial strategy whereby the coercer threatens to deny the enemy the prospect of success if its demands are not met.³³

Following these denial strategy modifications, Mueller proposes similar changes to the punishment and risk strategies. He proposes moving beyond Pape's fixation on the target population to include strategies that "raise the enemy's expected costs of resistance without actually attacking or tormenting the civilian populace."³⁴ One method of doing so may involve threatening or destroying targets that are valued by the government or population. As Mueller notes, "when the state and the populace cease to be synonymous, the difference between threatening, hurting, or frightening the state and the citizenry looms forth, and punishment and risk become far more interesting and varied than they are in Pape's original analysis."³⁵

One shortfall of Pape's coercive airpower analysis is his failure to discuss hybrid strategies that combine punishment and denial.³⁶ A particular example of such a strategy might call for the long-term destabilization of an adversary's government. Another might involve threatening the security of an adversary by weakening his ability to defend himself, or by strengthening his potential enemies.³⁷ "Such an 'endangerment' strategy would, depending on one's point of view, either

³¹ Pape., 69-72.

³² Mueller, 40.

³³ Ibid., 41.

³⁴ Ibid., 42.

³⁵ Ibid., 44.

³⁶ Ibid., 47.

³⁷ Ibid.

threaten what the enemy valued, to wit its national security, or place at risk its strategy for long term survival in the international system.”³⁸

This brief summary of Pape’s airpower strategies and Mueller’s proposed modifications to them hides some complexities that must be understood before a thorough assessment of the efficacy of Pape’s construct can be made. Major Thomas Ehrhard³⁹ analyzed some of these shortcomings and proposed useful modifications to Pape’s coercive airpower construct that can be applied in developing a framework for airpower application.

Ehrhard proposes a strategy analysis framework based upon Pape’s depiction of the linkage between military actions and policy outcomes. The genesis of this framework was the recognition that Pape’s construct had deficiencies that limited its broad application to strategic air planning. In Pape’s discussion of targets, Ehrhard recognized that many tactical and operational issues that drive the application of force were missing. He proposed that airpower capability was a central factor essentially ignored by Pape, a factor that virtually defines some airpower application strategies — such as Douhet’s virtually invulnerable battle planes.⁴⁰ He also noted that some airpower applications, such as strategic airlift during the Berlin crisis, did not fall within Pape’s taxonomy. For this reason he expanded the target construct to that of airpower actions. Within this construct, Ehrhard included employment tactics along with capabilities and targets. Ehrhard proposed that the mechanism, as discussed by Pape, lacked crucial internal structure despite the logical development of his argument concerning the efficacy of airpower strategies.⁴¹ He recognized that limiting desired political outcomes to policy changes is overly restrictive and eliminates the

³⁸ Ibid.

³⁹ Thomas Ehrhard. “Making the Connection: An Air Strategy Analysis Framework” (Maxwell AFB, Ala.: Air University Press, April 1996).

⁴⁰ Ibid., 9.

consideration of cases in which coercion may not be the overriding goal. For this reason, he expanded both the outcomes and mechanisms constructs to include the consideration of the principal target, domestic impacts, and third party reactions.⁴² Finally, Ehrhard proposed that the orientation of Pape's construct, from targets to outcomes, is backwards. He recommended reorienting it to reflect the necessity of considering the political objective before considering targets in developing an airpower employment strategy.⁴³ These changes add necessary structure and depth to Pape's construct. Unfortunately, Ehrhard did not go on to explore Pape's airpower employment strategies within this new construct. Nonetheless, the model, which is shown in Figure 3, is useful in the development of an airpower application framework.

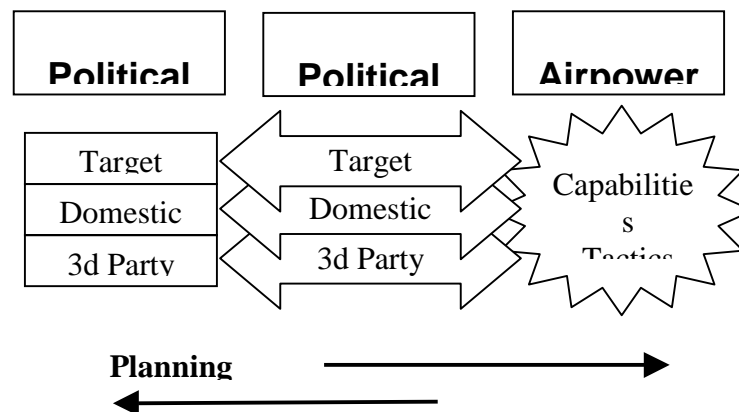


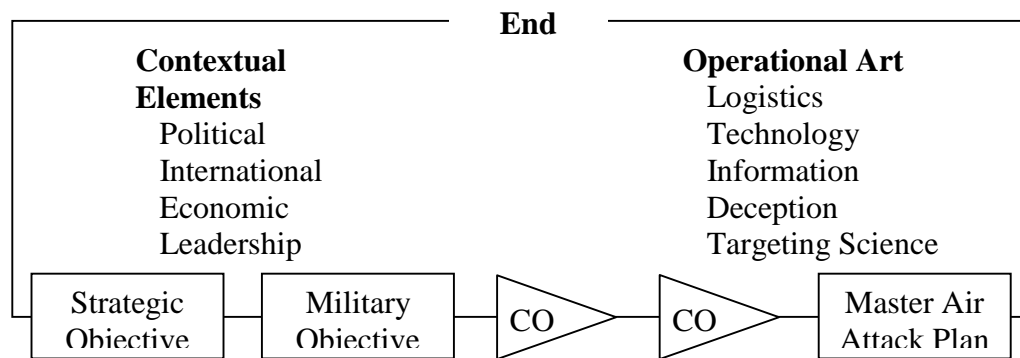
Figure 3. Air Strategy Analysis Framework
Source: Thomas Ehrhard, "Making the Connection"

The Air Command and Staff College (ACSC) Air Campaign Process Model adds the final elements needed to construct an airpower application framework. This model was developed by "an ad hoc group of ACSC faculty in response to Colonel Warden's mandate that the ACSC

⁴¹ Ibid., 10.

⁴² Ibid., 13.

curriculum should focus on problem-solving and strategic air campaign planning.”⁴⁴ While this model contains many of the same elements as Pape’s model, it concentrates more heavily on operational aspects of the air campaign.⁴⁵ Despite this, it highlights certain aspects of force employment at the national strategic level that Pape does not. These include a host of contextual elements that dramatically impact the effectiveness of any airpower employment strategy, the dependence of airpower strategies upon national strategic objectives, and the causal nature of the relationship between force application and strategic objectives. In particular, this model highlights the need for end-state planning in the development and execution of airpower strategies. This model is shown in Figure 4.



COG – Center of Gravity; COA – Course of Action

Figure 4. The ACSC Air Campaign Process
Source: Air Campaign Planning Course materials

The construction of an airpower application framework requires the synthesis of elements of each of the four models already discussed. Each of these constructs highlights essential processes and mechanisms that the air strategist must consider in the development of air strategies.

⁴³ Ibid.

⁴⁴ Ehrhard, 7; citing an interview with three members of the original ad hoc group, Lt Col Larry Weaver, Dr. Rich Muller, and Lt Col Gus Liby, conducted on 7 June 1995.

⁴⁵ Ehrhard, 8.

The Airpower Application Framework

The Airpower Application Framework (AAF) is structured to encourage the air strategist and modeling and simulation developer to consider a broad range of issues affecting airpower employment strategies. The model is structured to foster the consideration of these issues in a logical fashion both in the planning and execution phases of the campaign. Air strategy development begins with consideration of the national security strategy and the national security objectives derived from it. In considering these elements, strategists and planners must assess the numerous contextual factors that influence them and that influence the determination of the desired post conflict end-state. Military strategy must then be considered and the desirability of using military force to achieve the given objectives and end-state. A capability assessment must also be made to determine required and available resources. Next, the strategist or model developer must consider the pros and cons of particular airpower strategies given the national security objectives, national military strategy, and desired end-state.

Coercive strategies of denial, punishment/risk, decapitation, or some hybrid of these are most likely to be employed in conventional warfare and small-scale conflicts. When using these strategies, one must consider how the choice of strategy and the subsequent choice of targets will achieve the desired objectives. Herein lies the importance of the coercive mechanism. This mechanism, which has often been ignored or glossed over, lies at the heart of Pape's work and is the focus of discussion among airpower theorists. To provide insight for the airpower strategist and the political leader, model developers should incorporate a historical assessment of the effectiveness of available air strategies. While subjective, this database of experience is essential to move from a random employment of airpower to a structured and rational approach that effectively achieves political goals. Finally, the strategist must

consider the factors that directly affect the use of airpower in the theater of operations. These include the elements of operational art shown in the ACSC Air Campaign Process model as well as the target set and tactics. In the selection of target sets, the airpower strategist must consider the system level effects, which are highlighted by Warden's five-ring model. As airmen execute the campaign, the strategist must assess its effectiveness in light of the chosen strategy and its coercive mechanisms. Finally, the strategists and historical analysts must add the knowledge gained from air operations to the historical database. Figure 5, which depicts the Airpower Application Framework, illustrates the relationship of these elements.

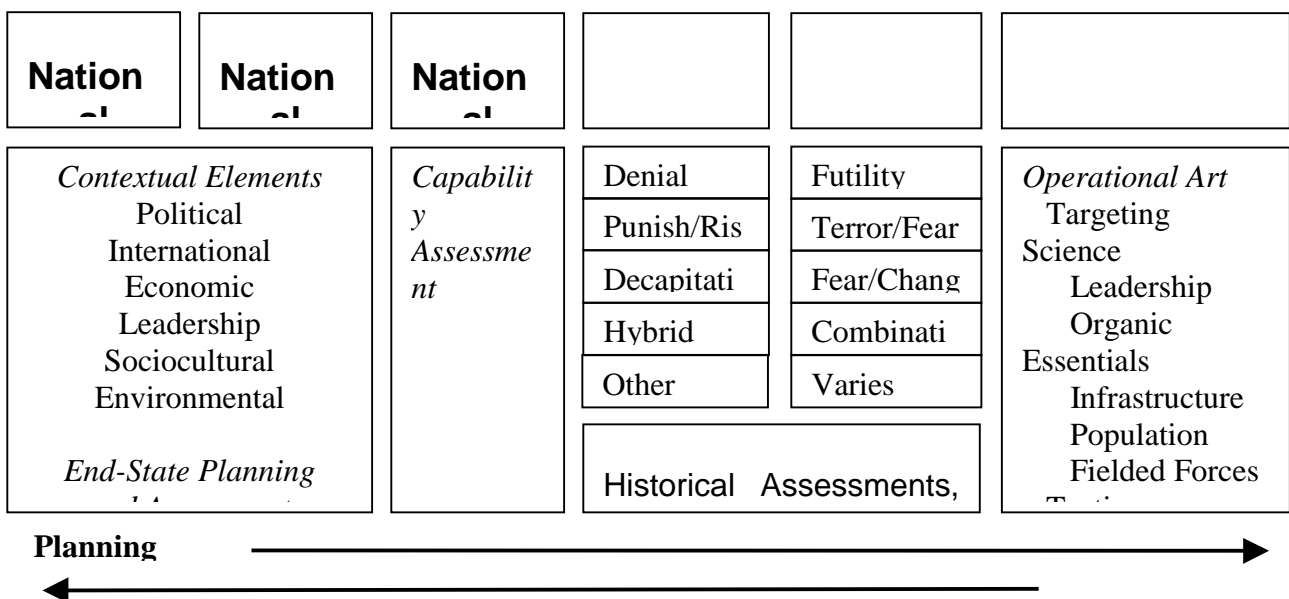


Figure 5. Airpower Application Framework

The elements of the Airpower Application Framework encompass all of the significant constructs found in the four models already discussed. For example, Ehrhard's Air Strategy Analysis framework explicitly called for consideration of the intended target as well as domestic and third-party impacts. These same considerations are found in the political and international contextual elements of the AAF.

Ehrhard also incorporated the need to consider available air power capabilities as is mandated in the capability assessment of the AAF. The airpower action element contains the operational art considerations found in the Air Campaign Process model. In addition, the necessity of considering many contextual factors, such as the desired end-state during strategy development and campaign execution is emphasized through use of the model during the planning and execution phases of the air campaign.

Pape's [target → mechanism → political outcome] construct as modified by Ehrhard forms the core process in the AAF. In conjunction with Mueller's clarifications of Pape's airpower strategies and coercive mechanisms, this process begins the codification of one of the most difficult aspects of airpower employment, that of understanding how the "ends" of policy are reached through the "means" of applied force. Pape's four principal airpower strategies have been modified here and expanded to enable the consideration of strategies not addressed in his taxonomy. In Ehrhard's development of the Air Strategy Analysis framework, he attempted to encompass this broader array of air strategies by generalizing his airpower actions analysis. This idea is carried forward in the Airpower Application Framework by including "hybrid" and "other" airpower strategy elements. Each of these elements and their corresponding coercive mechanisms are discussed in detail in Chapter Three. In addition, as a starting point for the M&S developer and airpower strategist, substance is added to the Historical Assessment of Effectiveness construct based upon Pape and Mueller's historical analysis of a number of air campaigns.

Chapter 3

AAF Employment Considerations

The complexity of coercion, like modern warfare, requires strategists and decision-makers who are expert in more than the military arts narrowly defined. In order to anticipate the effects of air attack not just on individual aim points and targets, but on the enemy's behavior, it is necessary to understand a great deal about how political systems, national economies, and armed forces function, react, and interact. Thus the strategist, if not personally an expert in politics (including warfare), economics, psychology, sociology, and organizational behavior, at least must be sufficiently conversant with these fields to recognize what he or she does not know, but needs to find out in order to make sound policy and effective strategy.

Karl Mueller, "Strategies of Coercion: Denial, Punishment, and the Future of Air Power"

The Airpower Application Framework is a tool for the airpower strategist or M&S designer in developing well reasoned approaches to airpower employment. As such, there are many caveats, assumptions, and limitations of which the strategist or designer must be aware in order to use it effectively. This chapter reviews the most important of these factors to include the type of conflict for which the model applies, the nature of coercive mechanisms, historical evidence of the effectiveness of coercive airpower strategies, and targeting effects at the system level.

Scope of the AAF

The three classes of warfare of interest to airpower strategists are nuclear, conventional, and smaller-scale contingency operations⁴⁶. Nuclear warfare, which is generally thought of as global nuclear war, is obviously concerned with the strategic use of weapons of mass destruction. While certain aspects of the Airpower Application Framework (AAF) may be applicable to nuclear warfare, it is not suited for the development of strategies in this context. Numerous documents, treatises, and articles exist on the vagaries of nuclear deterrence and coercion, all subjects that are beyond the scope of this thesis.⁴⁷

Conventional warfare is the primary focus of the AAF. Generally viewed as traditional force-on-force operations between states, conventional warfare falls into the class of operations known in DOD vernacular as major theater war (MTW). Because these operations are of foremost concern to defense planners, analysts, and strategists and because sufficient analysis exists of the relative effectiveness of coercive airpower strategies as applied to major theater wars, the following analyses concentrate on the effective use of the AAF in these operations.

Smaller-scale contingencies involve a vast array of activities from humanitarian operations through the enforcement of exclusion zones

⁴⁶ Smaller-scale contingency (SSC) operations appears to be the latest DOD renaming of military operations other than war (MOOTW). Although Air Force Doctrine Document 1, published in September 1997, still uses the term MOOTW, The 1998 Annual Report to the President and the Congress, produced by Secretary Cohen, references only SSC operations.

⁴⁷ For a comprehensive look at nuclear deterrence and coercion see, Thomas Schelling, *Arms and Influence* (New Haven: Yale University Press, 1966), Bernard Brodie, *Strategy In The Missile Age* (Princeton: Princeton University Press, 1965), Robert Jervis, *The Meaning of the Nuclear Revolution: Statecraft and the Prospect of Armageddon* (Ithica: Cornell University Press, 1989), Charles L. Glaser, *Analyzing Strategic Nuclear Policy* (Princeton: Princeton University Press, 1990), and Karl P. Mueller, "Strategic Airpower and Nuclear Strategy: New Theory for a Not-Quite-So-New Apocalypse" in *The Paths of*

and sanctions. Air Force Doctrine Document 1 describes them simply as military actions not associated with sustained, large-scale combat operations.⁴⁸ While many past contingencies have involved US attempts to coerce or deter an adversary, the relatively limited analysis of the effectiveness of these operations precludes their meaningful inclusion in the following discussion. However, the usefulness of the AAF for smaller-scale contingency operations should not be underestimated. The AAF's structured analysis of conventional airpower strategies is also applicable when these operations involve coercion.

A Look at Mechanisms

The mechanism by which the application of force is translated to the achievement of policy objectives is a critical link in the understanding and execution of coercive airpower strategies. Some of these mechanisms appear straightforward and reasonable. Others rely on cascading effects initiated by the populace's emotional reaction to attack. All are subjective. Quantification of such effects is virtually impossible beyond after action surveys of the people and leadership of attacked states. Nonetheless, without some attempt to understand, evaluate, and use these mechanisms, the effectiveness of airpower strategies is left to little more than a hope and a prayer.

The coercive mechanisms for each of the airpower strategies shown on the Airpower Application Framework differ markedly. In a denial strategy, the mechanism is the degradation of enemy capabilities to such an extent that success looks impossible, defeat looks inevitable, resistance appears futile, and the costs of continuing to resist outweigh the costs of surrendering. The punishment mechanism begins with the terrorization of the population. This terrorization theoretically leads to

Heaven: Evolution of Airpower Theory, ed. Phillip S. Meilinger (Maxwell AFB, Ala.: Air University Press, 1997), 279-320.

either popular revolt or the leadership's fear of it, which in turn forces a change in government and ultimately a change in policy. The risk strategy mechanism is driven simply by the fear of future loss, whereas the mechanisms of decapitation are more varied. Killing military or political leaders results in an obvious change of leadership and a possible change in policy. The leadership's fear of being killed may also result in a change in policy or strategic paralysis. In addition, the elimination of the leadership's C³ capabilities may lead to strategic paralysis, successful denial, and ultimately a policy change. The hybrid strategy mechanism is a combination of those of the strategies being used. For instance, the mechanism of a punishment-risk strategy may involve the terrorization of a segment of the population and the instillation of fear in the remaining population of being the target of similar attacks. Finally, the mechanism of "other" strategies is obviously as varied as the strategies used. Taking the endangerment strategy discussed earlier as an example, the mechanism is fear. Only in this instance the fear is not directly of death as in decapitation, but in the expectation of loss of sovereign control. While these are brief thumbnail sketches of coercive mechanisms, they provide a starting point for the consideration of their implications in the development and execution of coercive strategies.

The Historical Evidence of Effectiveness

Robert Pape, in *Bombing To Win*, attempts to analyze the effectiveness of coercive airpower strategies by undertaking a review of thirty-three conflicts in which such strategies were used. In this analysis, Pape attempts to correlate coercive outcomes and the degree of punishment inflicted upon a state's civilian populace. His interpretation of the evidence leads him to conclude that coercive success is more

⁴⁸ Air Force Doctrine Document , AFDD-1 (September 1997), 8.

closely related to denial than to punishment.⁴⁹ Unfortunately, there are several statistical and definitional flaws within this analysis that tend to reduce any substantive conclusion to a rather unsatisfying statement of the obvious.⁵⁰ Statistically, the case set includes “conflicts where strategic bombing (punishment, risk, decapitation, or denial through strategic interdiction) was threatened or used” as well as “a number of cases in which air power was virtually irrelevant to the ultimate result.”⁵¹ In addition, the case set “excludes many [conflicts] in which coercive air power was used against ‘non-strategic’ interdiction or ground support targets” and a number that “ought to have been included according to [Pape’s] stated selection criteria.”⁵² The end result of these needed modifications, according to Mueller, would be that “the successful prediction rate for denial could have been increased beyond almost any desired threshold of statistical significance.”⁵³ However, Pape’s clear oversimplification of the denial theory reduces the number of cases to six in which the predictions of punishment and denial theories diverge.⁵⁴ The result is thus a “general impression that denial appears to be a necessary but not a sufficient condition for coercive success, while punishment of civilians is neither sufficient for success...or necessary. [The analysis however] does not prove that punishment does not work, only that it does not *always* work.”⁵⁵

Pape presents five case studies of coercive airpower in major conflicts (Japan, 1944-1945, Korea, 1950-1953, Vietnam, 1965-1972, Iraq, 1991, and Germany, 1942-1945).⁵⁶ The cases provide significant insight into the functioning of coercive strategies. One of the most

⁴⁹ Mueller, 15.

⁵⁰ Ibid., 19.

⁵¹ Ibid., 16.

⁵² Ibid.

⁵³ Ibid., 17.

⁵⁴ Ibid., 18.

⁵⁵ Ibid., 19.

significant results of this analysis is the critical importance of national interests in determining the effectiveness of coercive strategies. In the use of punitive strategies “it is natural to ask whether what is being threatened or destroyed is more or less valuable to the target state than the concessions being demanded. But it is equally true for coercion by denial, because it determines what must be denied in order for coercion to succeed.”⁵⁷ Thus, a strategist must always consider the target’s cost-benefit analysis of conceding versus continuing to fight and use this assessment to manipulate, if possible, the target’s expectations. As Mueller notes, “states may well be able to alter the anticipated benefits of resistance by manipulating either their demands or the enemy’s expectations of how unpleasant surrendering would...be.”⁵⁸ Pape goes on to assess other aspects of punishment and denial as well as the effectiveness of risk and decapitation strategies across these five historical cases, eventually drawing a number of important conclusions. Mueller adds insight to these arguments ultimately arriving at a comprehensive distillation of historical evidence that is of particular importance for the effective use of the Airpower Application Framework.

Pape and Mueller provide critical insights into the effectiveness of coercive airpower strategies for the airpower strategist and model developer. These are summarized as follows: 1) denial can coerce and appears necessary particularly when vital interests are at stake; 2) denial may not be necessary in cases where stakes are more limited; 3) operational interdiction has proven itself highly effective in many conflicts and should continue to do so, particularly with the advent of precision guided munitions; 4) strategic interdiction is only likely to be effective in protracted conflicts in which substantial resources are consumed; 5) punitive strikes against the civilian populace have proven

⁵⁶ Ibid., 87-313.

⁵⁷ Ibid., 20-21.

⁵⁸ Ibid., 21.

largely ineffective and are politically unpalatable as well; 6) punitive strikes against assets valued by the state or its leaders are potentially coercive in low stakes conflicts; 7) risk strategies in low stakes conflicts may also be coercive and should be politically attractive for their cost-minimizing potential; 8) decapitation has not proven itself an effective coercive strategy, but neither as it been proven ineffective—the jury is still out, but the case in its favor looks doubtful; 9) coercive airpower is seldom effective when used in isolation from other instruments of national power regardless of the stakes.⁵⁹ An important aspect of this analysis is that airpower coercion is not an “all-or-nothing” affair. It is a contributor to the larger effort of achieving national security objectives, an effort that inevitably involves many instruments of national power and often other states.

Targeting Effects

Another area of consideration, intimately tied to the effectiveness of coercive strategies and mechanisms, is targeting effects. Targeting effects consist of the physical system-level responses to the application of force against a component of the enemy system. In Warden’s five-ring analysis, these sub-system components consisted of leadership, organic essentials, infrastructure, population, and fielded forces. The effectiveness of coercive mechanisms, and ultimately coercive strategies, is highly dependent upon a thorough understanding of these five sub-systems, their interrelationships, and the methods of efficiently disabling or destroying them.

Targeting leadership and organic essentials, Warden’s innermost rings, is generally considered a punishment strategy. The mechanisms involved and the historical evidence of its effectiveness are described above. Let us suppose however, the decision is made to pursue this

⁵⁹ Ibid., 26-28.

strategy despite its low probability of success. How does the strategist and model developer approach individual target selection to maximize effectiveness? Warden simply advocated a reductionist approach where by successive COGs within the target systems were selected and deconstructed until a “true” COG was found.⁶⁰ Although this is an accurate description of the process, a more structured technique is needed for implementation.

Modeling inter-system and intra-system effects begins with the deconstruction of a single system. Deconstruction of the gas distribution system within the organic essentials target set, for instance, requires substantial intelligence concerning system nodes and links, such as generation plants, pump stations, and supply lines. Fortunately for the strategist, this information is easily incorporated into existing modeling programs of these physical systems. Linkages are drawn between these individual sub-systems until a complete model of the organic essentials target set exists. With this model the strategist is able to assess critical system-level effects, such as the cascading disruption of the electrical power grid from the destruction of a small number of gas generation plants. The effectiveness of the analysis and the wide-spread disruption of a system due to relatively limited damage depends upon system coupling and non-linear effects. While this example only concerned the organic essentials target set, interdependencies exist not only within Warden’s five systems, but between them as well. Thus, it takes little effort to visualize the complexity involved in targeting at the system level to achieve strategic objectives and the need for a variety of tools to help the strategist do so. Fortunately, many efforts are underway to provide the models and simulations needed to flesh out the various elements of the Airpower Application Framework. These are discussed in Chapter Four.

⁶⁰ John A. Warden, III, “The Enemy As A System,” *Airpower Journal* 9, no. 1 (Spring 1995): 46.

Chapter 4

Modeling and Simulation

M&S is used everywhere in the Air Force because better decisions and better training make better warfighters.

1995 U.S. Air Force

Modeling and Simulation Master Plan

The Airpower Application Framework is an architecture for assembling a collection of models that, when properly used, aid a strategist in developing courses of action with a reasonable chance of success. Within its various elements lies the requirement for a variety of M&S tools that range from mathematical models of physical components to strategic analysis simulations involving our most senior military and civilian leaders. The development of these models and simulations is an enormous effort under the direction of a multitude of agencies and organizations. Yet this enormous effort can be traced to the strategic models of war in use by the Chinese over 5000 years ago. The historical development of these wargames provides some important insights into today's wargaming efforts and the future of modeling and simulation.

Historical Antecedents

Modeling and simulation, in the form of wargames, has a long history of use as a tool for enabling political and military leaders to make better strategic decisions. Although the origin of the wargame is unknown, scholars generally acknowledge its derivation from the Hindu

game of *Chaturanga*, which flourished 3,000 to 4,000 years ago.⁶¹ *Chaturanga*, a board game that used a stylized map and gaming pieces was eventually adopted by the Europeans and simplified into the game of chess. In 1644, Christopher Weikhsman developed “King’s Game,” a form of war chess. This board game, which consisted of 30 pieces on each side, was highly regarded as an aid in military training.⁶² As warfare became progressively more complex, board games evolved to reflect reality. Game pieces came to represent military units instead of individual soldiers and game rules expanded dramatically. *Neues Kriegsspiel* was the most elaborate of this type of game. Developed around 1800, this game had sixty pages of rules, 2600 game pieces, and was played on 3,600 squares depicting actual terrain on the Franco-Belgian border.⁶³

With its adoption in Prussia, *Neues Kriegsspiel* evolved to more closely reflect the real conditions of war. Maps replaced the game board, red and blue scaled pieces representing infantry, cavalry, and artillery units of both armies were introduced, die were used to simulate chance and the fog of war, and time limits were established for the movement of pieces.⁶⁴ Eventually, the rigidity of the game led to the development of a “free” version that essentially did away with the detailed rules of play and the use of die. *Frei Kriegsspiel* incorporated the use of an umpire to guide game play and set the standard for subsequent wargame development. By the turn of the 20th century, German officers were playing campaign

⁶¹ Francis J. McHugh, Fundamentals of Wargaming (Newport, RI: Naval War College, 1966), p. 2-1. Also, Daniel B. Fox, “A Conceptual Design for a Model to Meet the War-Gaming Needs of the Major Commands of the United States Air Force,” Research Report, Air University Press, Maxwell Air Force Base, AL, 1986, p. 9.

⁶² Andrew Wilson, *The Bomb and the Computer: Wargaming From Ancient Chinese Mapboard to Atomic Computer* (New York: Delacorte Press, 1968), 2.

⁶³ Ibid.

⁶⁴ Ibid.

and strategic level games that would prove instrumental in the planning and analysis of operations leading to WWI.⁶⁵

Wargaming was adopted by the American and British military establishments as a cost-effective method of training commanders. Initially, the US and Britain found themselves behind Germany in simulating tactical and strategic engagements. However, by 1914 the efforts of Spenser Wilkinson, a prominent British military reformer, and Major W.R. Livermore, the most widely read American authority on wargaming of the early Twentieth century, led to substantial improvements in this area.⁶⁶ Foremost among the organizations conducting wargames was the Naval War College. Conclusions drawn from the conduct of a large number of games compelled naval officers to make substantive recommendations that influenced the conduct of operations during the First and Second World Wars.⁶⁷

World War II saw the extensive use of wargames and the development of the field of operations research, the foundation of the modern modeling and simulation discipline. In 1939, a small group of civilian scientists were directed to investigate several significant operational problems.⁶⁸ One of the first recommendations from this group resulted in a dramatic increase in the number of German submarines destroyed by Allied aircraft.⁶⁹ From these beginnings, operations research grew in two distinct directions. The first was its use to analyze and improve the performance of weapon systems. The second

⁶⁵ Robert A. Rosenwald, "Operational Art and the Wargame: Play Now or Pay Later," Monograph, School of Advanced Military Studies, US Army CGSC, Fort Leavenworth, Kansas, Second Term, AY 89/90, p. 14.

⁶⁶ Wilson, 9-14.

⁶⁷ Ibid., 20.

⁶⁸ Ibid., 45.

⁶⁹ The recommendation was to modify the fusing of the bombs to decrease the depth at which they exploded. This recommendation was the result of a statistical analysis of the occasions in which the U-Boat failed to detect incoming aircraft

was its use to analyze major operations to determine more effective strategies for accomplishing objectives, while reducing cost. Operational research proved such a valuable tool that analysts continued to use it to improve all fields of military endeavor from battlefield tactics to the procurement of weapon systems. However, the development of the atomic bomb and the rise of the Cold War forced the development of entirely new methods of simulation and analysis designed to generate ideas, acquire data, and gain insight into the future.

From politico-military strategy games to the modeling of ICBM trajectories, modeling and simulation received wide-spread recognition for its value-adding ability as the Cold War continued. Consequently, the armed services embarked upon a range of efforts to codify and quantify the knowable and unknowable. The US Joint War Games Agency, MIT, the newly created RAND Corporation, and Stanford Research Institute among others began the enormously difficult task of attempting to model systems in which human behavior was the dominant factor.⁷⁰ Meanwhile, tactical level simulations, as typified by the Marine Landing Force War Game and Navy Electronic War Simulator increased in complexity. Eventually, these games and simulations moved from the machine assisted realm to true computer simulations. Statistical games involving random Monte Carlo processes were introduced to add realism to the models, while the use of game theory to model national and international relations received growing attention.⁷¹

By the 1990's, modeling and simulation efforts had grown so large and in such an uncoordinated manner that the Department of Defense was forced to create an organization specifically tasked to reduce waste and inefficiency in the process. This organization, known as the Defense

and initiate evasive maneuvers. In these instances, the shallower fusing resulted in much higher kill ratios. See Wilson, 47-48.

⁷⁰ Wilson, 63-80.

⁷¹ Ibid., 81-184.

Modeling and Simulation Office is now the hub of all major defense modeling and simulation activities.

Current M&S Initiatives

Department of Defense modeling and simulation efforts are focused on enhancing all aspects of military capability and efficiency. There is literally no area of deployment, employment, training, analysis, acquisition, or planning that current modeling and simulation efforts do not directly or indirectly impact. Because of this, the Defense Modeling and Simulation Office (DMSO) was chartered in 1991 to: “promote the use of interoperability standards and protocols; establish DoD cognizance of, and facilitate coordination among, the department’s M&S activities; and, to stimulate joint use, high return modeling and simulation investment.”⁷² While the list of DMSO activities is extensive, the cornerstone of its efforts is the High Level Architecture (HLA).

The High Level Architecture (HLA) is a “DoD-wide simulation architecture intended to promote interoperability among simulation systems and encourage reuse of simulations and their components.”⁷³ It does this by specifying and enforcing compliance with the rules, interface standards, and object model templates to which DoD M&S efforts must conform.⁷⁴ The High Level Architecture is managed by the Defense Department’s Executive Council for Modeling and Simulation (EXCIMS) through its Architecture Management Group and is the highest priority

⁷² Walter N. Lang, “The Revolution Represented by The DMSO,” *National Defense*, November 1992, 9.

⁷³ John Knowles, “DISing the Real World: Modeling and Simulation Get Some Respect,” *Journal of Electronic Defense*, November 1995, 40.

⁷⁴ Paul G. Kaminski, Under Secretary of Defense (Acquisition and Technology), to Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, et. al., letter, subject: DoD High Level Architecture (HLA) for Simulations, 10 September 1996.

effort within the DoD M&S community.⁷⁵ The HLA is, however, only a framework upon which to build modeling systems. While the systems being developed for use within the HLA environment are too numerous to fully discuss here, it is necessary to review a few of the most salient programs.

The Joint Warfare Simulation (JWARS) system is a distributed, object-oriented system focused on joint campaign analysis.⁷⁶ This program simulates the interaction of land, sea, and air forces across different types of campaigns to develop strategies for the most effective use of military forces and battlefield data.⁷⁷ A significant focus of the JWARS system is to “further the evolution of military doctrine...from waging wars of attrition to engaging in efforts that rely principally on information operations.”⁷⁸ It is being developed as part of the Joint Analysis Model Improvement Program directed by the Deputy Secretary of Defense.⁷⁹

The Joint Simulation System (JSIMS) is also a distributed, object-oriented M&S architecture focused on the operational level of war.⁸⁰ This campaign and mission level effort however, is being developed in response to the inability of existing systems to accurately represent space, mobility operations, and offensive airpower.⁸¹ JSIMS, unlike JWARS, is focused more heavily on training than on analysis. It is expected to be capable of enhancing joint battlestaff training by 1999. The Air Force is building the red and blue component models that “plug-

⁷⁵ “DoD High Level Architecture (HLA),” on-line, Internet, 13 January 1998, available from <http://hla.dmsso.mil/hla/main.html>.

⁷⁶ United States Air Force Pamphlet, *Air Force Modeling and Simulation: A New Vector*, 12.

⁷⁷ “Models, Simulations Converge, Close on High-Level Architecture,” *Signal*, July 1997, 43.

⁷⁸ Ibid.

⁷⁹ USAF Pamphlet, 12.

⁸⁰ Ibid.

⁸¹ Ibid.

in” to the JSIMS architecture, such as aircraft and satellites, through the National Air and Space Model (NASM) program.⁸² “NASM is focused on the development of a flexible framework for representing the full range of air and space capabilities at the operational level.”⁸³

The Joint Modeling and Simulation System (J-MASS) is an “Air Force-directed program to develop and deliver a distributed, object-oriented M&S architecture and system that is focused on the tactical level of war.”⁸⁴ This mission and engagement level program provides a “common environment for tactical modeling across the requirements development, acquisition, and test process.”⁸⁵ J-MASS is populated with “authoritative representations of Air Force and threat systems (e.g., surface-to-air missiles, aircraft, etc.) that interoperate and comply with J-MASS standards.”⁸⁶ Beyond J-MASS, there are an enormous number of efforts such as the close combat partial trainer, battle force tactical trainer, joint combat tactical training system, and several natural environment simulations all designed to prepare the US military to fight and win.⁸⁷

The integration of these various efforts, from JWARS campaign level simulations to J-MASS hardware simulations, will provide warfighters an unparalleled capability to organize, train, and equip. Unfortunately, what none of these efforts do is aid US civilian and military leadership in making the connection between the *ends* of national security policy and the military *means* of achieving it. As such, these deterministic and predictive models form the core analysis tools within the Airpower Action element of the AAF. While answering “how” at the tactical and operational levels is certainly critical, the AAF requires

⁸² *Signal*, 46.

⁸³ USAF Pamphlet, 11.

⁸⁴ *Ibid.*

⁸⁵ *Ibid.*

⁸⁶ *Ibid.*

⁸⁷ “Joint Simulation Facilitates Training Realism Concepts,” *Signal*, July 1997, 39.

much more than that. Consequently, we must turn to very different M&S approaches for aid in determining whether to pursue a coercive strategy and if so, which one.

Modeling Strategic Analysis

Models used for strategic policy analysis are fundamentally different from those used in the classical sense of the hard sciences and engineering disciplines. Whereas the latter can be, and often are, used in a predictive sense, the reality of the environments of concern to policy makers cannot be predictively modeled. A significant danger in the use of models for policy analysis is that these models “provide an illusion of analytic certainty for problems that are not that well understood or, in the worst cases, provide scientific costume for points of view that are self-serving.”⁸⁸ To address this issue, a new approach developed at RAND uses exploratory modeling to support the analysis of complex problems for which validation of the correctness of the model is not possible.

The goal of exploratory modeling is the elucidation of a compelling argument rationalizing a policy choice from among a set of policy options. In constructing such an argument, a number of question driven models must be built and used to develop the line of reasoning. Since it is not possible to develop these models for all potential outcomes, this reasoning generally focuses on the analysis of critical cases that support a particular policy choice. Thus, even non-predictive models can be used to reveal facts that are true of all possibilities or to provide convincing arguments by example. However, it must be remembered that the central result of this exploratory approach is an argument, not the output of a given model.⁸⁹

⁸⁸ Steven C. Bankes, *Exploratory Modeling and the Use of Simulation for Policy Analysis*, RAND Report N-3093-A (Santa Monica, Calif.: RAND, 1992), v.

⁸⁹ This paragraph is paraphrased in its entirety from Bankes, vi.

Another way to pose this problem of producing a compelling argument for a given policy alternative is as a search. “The goal of the search is [a conclusion or set of] conclusions that can be safely drawn despite incomplete or imperfect knowledge.”⁹⁰ The conclusions “correspond to facts or relationships that are invariant across all plausible models”⁹¹ and only have meaning in the context of the assumptions and limitations used in the development of these models.

Although exploratory modeling is a question-driven approach, the data used in the development of the plausible models is very important to the quality of the argumentative result. Because of this, the input data should be derived from a number of sources. Of obvious importance is data provided by experiments, simulations, and exercises. In the AAF, data is derived from the use of the many predictive models within the Airpower Action element. In addition, historical analysis, systematic interviews of experienced officers, politicians, and diplomats, and the results of politico-military games and studies are other critically important classes of information that must be used. This information is represented by the Historical Assessments, Interviews, and Studies element of the AAF. In the past, too little effort has been made to systematically collect, structure, and exploit this type of information. One exception however, has been the work of Colonel Trevor Dupuy, USA (Ret), who has been instrumental over the years in using historical information in the development of highly aggregated combat modeling.⁹²

⁹⁰ Bankes, 12.

⁹¹ Ibid.

⁹² Paul K. Davis and Donald Blumenthal, *The Base of Sand Problem: A White Paper on the State of Military Combat Modeling*, RAND Report N-3148-OSD/DARPA (Santa Monica, Calif.: RAND, 1991), 7.

*In Numbers, Predictions, and War: The Use of History to Evaluate and Predict the Outcome of Armed Conflict*⁹³, Dupuy presents the Quantified Judgment Model (QJM), which he developed for the evaluation and prediction of combat outcomes. Dupuy developed this model to aid the military in preparing for strategic contingencies through the evaluation of recent historical battles. In the model, he assesses a multitude of factors such as Force Mobility, Combat Power, Relative Combat Effectiveness, Ammunition Supply Effect, Exhaustion, Morale, and Leadership across more than 250 battles from the Napoleonic battles of Austerlitz and Waterloo to the Israeli 1982 Bekaa Valley campaign. While critics have questioned Dupuy's methodology and the rigor of his mathematics, the implications of the work are nonetheless substantial. The ability to assess combat outcomes using both relatively easily quantified factors, such as weapon effects, and highly subjective ones, such as troop morale, should present valuable insights for use in the Airpower Application Framework's exploratory analysis.

The DoD has also recognized the need to represent human behavior in the M&S environment. The DoD M&S Master Plan, which guides the M&S efforts and organizations throughout the military, commits the Defense Department to establishing authoritative representations of human behavior as both individuals and within groups and organizations.⁹⁴ The Defense Modeling and Simulation Office has taken on the responsibility of organizing this research and has conducted a series of workshops to assess the issues and technologies involved. A report on the results of these workshops and follow-on discussions is due in April 1998.⁹⁵

⁹³ Trevor N. Dupuy, *Numbers, Predictions and War: The Use of History to Evaluate and Predict the Outcome of Armed Conflict* (Fairfax, Virginia: HERO Books, 1985).

⁹⁴ DOD 5000.59-P, *Modeling and Simulation Master Plan*, October 1995

⁹⁵ "Human Behavior Representation (HBR): Introduction," on-line, Internet, 13 January 1998, available from <http://www.dmsi.mil/projects/hbr/intro>.

As described in the introduction to this chapter, the Airpower Application Framework provides a foundation for systematically using a collection of models to aid strategists in developing and executing coercive airpower strategies. For it to do so, the M&S developer must implement a variety of M&S techniques ranging from the construction of simple descriptive models, to the development of complex predictive simulations, to the formation of entirely new theories for assessing the unpredictable. The benefits of implementing the AAF should be substantial. Unfortunately, the challenges in doing so are enormous. These challenges are the subject of Chapter Five.

Chapter 5

Issues and Challenges

The purpose of computing is insight, not numbers.

Richard Hamming, 1962

Modeling and simulation holds the promise of dramatically improving efficiency in the planning and execution of military operations. Unfortunately, a “promise” may be all it holds in some areas. The challenge of developing decision aids for policy, strategy, and mission analysis is substantial. This chapter addresses some of these challenges and the activities needed, or underway, to resolve them.

Modeling the Airpower Application Framework

The Airpower Application Framework consists of a number of interrelated elements designed to assist an airpower strategist in determining a rational approach for using airpower to achieve political objectives. These elements, which range from national security concerns to tactics, require the strategist to consider many highly interdependent factors across a broad spectrum of policy and employment issues. To aid the strategist in this task, the framework necessitates the use of a number of models and simulations. Some of these, such as the Joint Warfare Simulation and Joint Simulation System, are under development by the DoD. Others, such as those needed for national policy analysis, exist primarily as training exercises and methodologies, not as actual models or simulations. Exploratory modeling, the methodology presented

for policy analysis in Chapter Four, may enable the practical development of the AAF. However, there is much work to be done before this can occur.

The relationship between the DoD development efforts, M&S methodologies, the AAF elements, and the M&S system hierarchy is depicted in Figure 6.

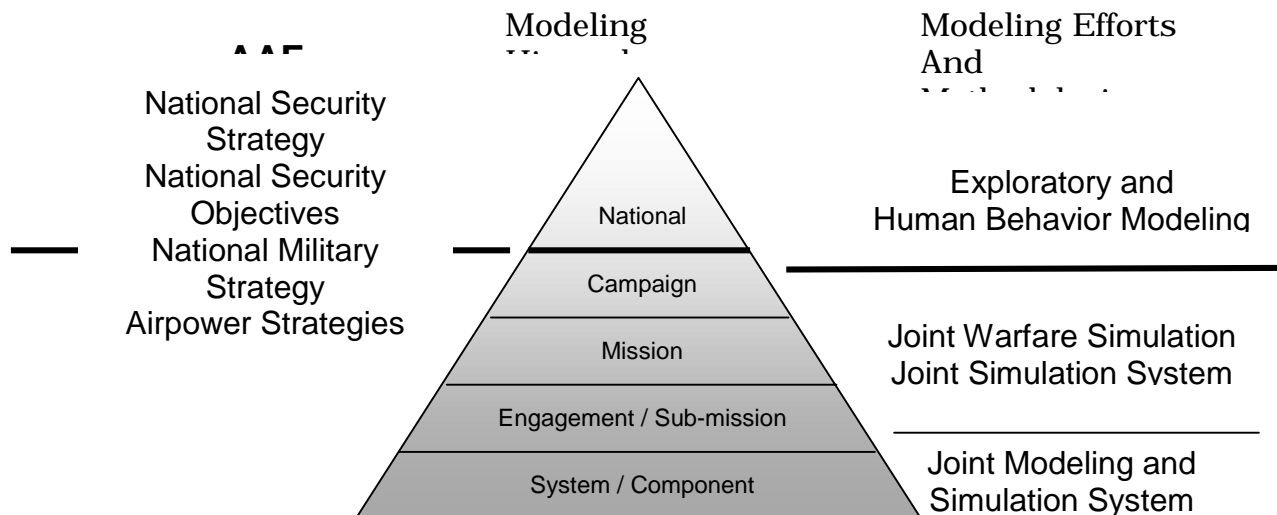


Figure 6. Modeling and the Airpower Application Framework
Source: Modified from William McQuay, "Air Force Modeling and Simulation Trends"

This illustration presents the concepts and systems discussed in the first four chapters of this work. Below the dark line separating National level models from Campaign level models, the Air Force and Department of Defense are deeply engaged in M&S efforts that integrate directly into the airpower action element of the Airpower Application Framework. Above the line, substantial effort is needed to develop the policy models required by the associated AAF elements.

The Air Force and Defense Department must expand their efforts in two primary areas in order to develop the models required for the implementation of the AAF. The first requires the DoD to undertake a deeper investigation of human behavior modeling in an attempt to understand the psychological effects of warfare, and in particular

airpower, on the military and civilian population of a target state. This effort feeds directly into the Historical Assessments, Interviews, and Studies element of the AAF and is the foundation upon which judgements concerning coercive mechanisms and airpower strategies are made. Without this understanding little can be expected of policy analysis modeling efforts.

The second area requires the DoD to undertake a more thorough investigation of exploratory modeling and the development of a host of single-question policy models that form the base model set for the exploratory analysis. To date, published works on exploratory modeling have been limited to conceptual discussions of its applicability to policy analysis and to high-level investigations of tactical operations⁹⁶. Formal investigations of policy analysis using exploratory modeling methods have yet to be undertaken. Consequently, there is much theoretical and developmental work to do before it becomes possible to implement the AAF as a decision aid. However, there has been enough investigation of exploratory modeling to provide a basis for this development effort. Besides the necessity of the DoD and Air Force addressing these two areas, there are several other concerns that must be assessed in the implementation of the Airpower Application Framework. A discussion of the most important concerns follows.

General Criticisms of M&S Efforts

Modeling and simulation efforts have drawn consistent criticism from a wide range of developers, users, and analysts. The reasons for this are many, but they become most apparent in large modeling efforts such as those currently underway. Steven Bankes, an M&S expert at the RAND Corporation, notes some of these problems. First, modeling efforts

tend to be large (from a line of software code perspective) and continue to grow throughout their use. Growth occurs because a constant reassessment of a model's performance demand updates and modifications as bugs, poor representations, changing requirements, and new uses are identified. Second, verification of the program's performance against the conceptual model can be extremely difficult. Despite this, verification and validation of a model, particularly those of the more deterministic and predictive variety, is critical. Third, the size and complexity of the model may make understanding how it works problematic. While documentation usually aids in understanding, it is often poor or incomplete. This necessitates an unhealthy reliance upon the developer for confirmation that the model performs as advertised. Fourth, problems with input and output sensitivity analysis are common. It is often extremely difficult to determine the relationship of output sensitivity to input uncertainty. In addition, developers may underestimate or ignore uncertainty and inaccuracy in the models' inputs and assumptions. Finally, model developers tend to focus on phenomena that can be readily modeled, while neglecting or ignoring phenomena that are difficult to model. This produces a systematic bias in the results that may be difficult to identify and correct.⁹⁷ The impact of these concerns is the development of models that tend to "rationalize institutional prejudices,...drive out careful thinking,...and provide an illusion of analytic certainty for problems that are not well understood."⁹⁸ This point is particularly salient in today's data-driven technological environment.

⁹⁶ Paul K. Davis and Manuel J. Carrillo, *Exploratory Analysis of "The Halt Problem": A Briefing on Methods and Initial Insights*, RAND Documented Briefing DB-232-OSD (Santa Monica, California: RAND, 1997).

⁹⁷ Steven C. Bankes, *Exploratory Modeling and the Use of Simulation for Policy Analysis*, RAND Report N-3093-A (Santa Monica, Calif.: RAND, 1992), 5.

⁹⁸ *Ibid.*, 6.

The limitations of current information and modeling technologies poses a number of significant issues that impact all areas of M&S. Major Maggie Belknap, a systems engineering professor at the Military Academy and an instructor at the Naval War College makes this observation. “If confronted with an enemy sniper in a darkened room would you want more ammunition, a larger caliber weapon, or night vision goggles? Those who make decisions on how to man and equip our forces depend on models that cannot answer this question. Born of the industrial age, they are inadequate for the information age.”⁹⁹ The defining criticism here is that industrial age force-on-force attrition models were designed to address incremental changes to force structure or weapon systems. They were not designed and cannot address the impact of rapidly evolving technologies, information warfare, and asymmetric employment strategies. Current force-on-force models “emphasize kill rates and weapon efficiency factors.”¹⁰⁰ If the DoD simply continues to retool them, it may “fail to capture potential innovations and commensurate force structure and cost savings.”¹⁰¹ To avoid this, the Defense Department should focus on C⁴I developments and their impact on force structure requirements. In doing so, it may develop M&S techniques that enable it to revolutionize warfare through information dominance, rather than continue automating its doctrinally stagnant attrition models. In the development of new techniques, an important consideration will be the ability to verify and validate the model’s output.

Verification, Validation, and Accreditation

A defining characteristic of most useful models is the ability to empirically verify their output. While this is a relatively straightforward

⁹⁹ Major Maggie Belknap, “The Force-On-Force Model: An Anachronism in the Information Age,” *Joint Forces Quarterly*, Spring 1997, 116.

¹⁰⁰ Ibid.

¹⁰¹ Ibid., 117.

process in many deterministic models, it is not possible in all circumstances. In particular, validators may be unable to design and carry out the necessary real-world experiments; the available historical data may be inadequate; the available theory may be insufficiently mature to allow the development of models capable of making predictions; the initial or boundary conditions of cases of interest may be unknown; or non-linearities may result in dramatic changes in the model's output due to minor deviations in its inputs.¹⁰² To overcome these limitations, it may be possible to validate submodels, obtain model parameters from validated sources, or predict the general characteristics of the system in lieu of specific details.¹⁰³ While these options are useful in reducing the total amount of uncertainty in the model's output, some uncertainty will remain. In addition, depending on the type of model under investigation, this uncertainty may be significant. Such is the case with models used for policy and strategic analysis.

The range of models required by the Airpower Application Framework vary widely in their ability to be validated. The J-MASS models are based in large part on physical systems. As such, the output of these models can be compared with experimental evidence gathered on the system being modeled. JSIMS and JWARS are campaign-level models whose validity will be determined primarily through the validation of their submodels. However, the validation of exploratory models of coercive airpower will not be possible. Yet, this does not reduce their usefulness. Strategy analysis models are not, and are not intended to be, predictive. Since they are decision aids used to advance and clarify an argument, it is the user of the model who must ultimately be satisfied with the logic and reasonableness of the argument.

The DoD recognizes the critical need to verify, validate, and accredit its models to the greatest extent possible. For this reason, it has

¹⁰² Bankes, 7.

chartered a technical working group under the Executive Council for Modeling and Simulation whose single mission is to guide the development of verification, validation, and accreditation (VV&A) policies and standards. The scope of this mission “extends to all models and simulations used by DoD and contractors in support of DoD-sponsored tasks.”¹⁰⁴ The verification, validation, and accreditation technical working group’s specific responsibilities include assessing VV&A technological developments, making programmatic recommendations to the Defense Modeling and Simulation Office (DMSO), acting as the interface to, and forum for, the VV&A community, and providing direct support to selected DMSO-funded projects.¹⁰⁵ In the past, many critics of DoD modeling efforts noted the desperate need for just such an organization. With its establishment, there ought to be more confidence in the results of future modeling efforts.

Common M&S Failings

There are several pitfalls found in current modeling and simulation efforts that merit close attention in the development of the AAF and its submodels. These include the tendency of model developers to focus on the technology of the model rather than its substance, unwise attempts to predict the unpredictable, and the misuse of time compression.¹⁰⁶ The abundance of data now available and the rapid evolution of the computer have brought numerous benefits to the field of operations research and the M&S discipline. Unfortunately, data and computing evolution has brought a host of problems related to the sometimes over-enthusiastic

¹⁰³ Ibid.

¹⁰⁴ “Charter of the Verification, Validation, and Accreditation Technical Working Group,” on-line, Internet, 13 January 1998, available from <http://www.dmsomil/wrkgrps/twg/vva charter.html>.

¹⁰⁵ Ibid.

embrace of new technologies. The ability to analyze and tabulate vast amounts of raw data have led to the development of large, complex models that provide prodigious amounts of information. The development of sophisticated networks and computer systems have led to distributed interactive simulation and the incorporation of human interfaces. The growth of high-resolution 3-D computer graphics and virtual reality has led to more realistic recreations of battlefield environments. Yet, these advances, however glamorous, often divert attention from the “substance of the models and the validity of the lessons that will be learned from them.”¹⁰⁷

In a similar manner, model developers often misrepresent the capabilities of M&S by attempting to predict the unpredictable. The very basis of modeling and simulation is the desire to make scientifically accurate predictions based upon historical or empirical evidence. This manifests itself in the often-implicit use of a predictive modeling paradigm “even when the impossibility of experimental validation is well recognized.”¹⁰⁸ This paradigm is an attempt to “capture the causal dependencies of the target system and thus yield both an improved understanding of the nature of the system and an ability to make predictions about the target system’s behavior.”¹⁰⁹ While this is possible in many models of interest to the Air Force and Defense Department, it is not in those designed for policy and strategic analysis. This is not to say that constructing these types of models is of limited use. On the contrary, the proper development and application of policy and strategic analysis models can provide significant insight into these complex issues. In “Exploratory Modeling for Policy Analysis,” Steven Bankes

¹⁰⁶ Paul K. Davis and Donald Blumenthal, *The Base of Sand Problem: A White Paper on the State of Military Combat Modeling*, RAND Report N-3148-OSD/DARPA (Santa Monica, Calif.: RAND, 1991), 6-10.

¹⁰⁷ Ibid., 6.

¹⁰⁸ Bankes, 8.

¹⁰⁹ Ibid.

makes this distinction between modeling efforts. “Exploratory modeling is using computational experiments to assist in reasoning about systems where there is significant uncertainty. While frequently confused with the use of models to consolidate knowledge into a package that is used to predict system behavior, exploratory modeling is a very different kind of use, requiring a different methodology for model development.”¹¹⁰ The development of exploratory models requires a recognition of the nature of the problem and a conscious avoidance of the predictive model paradigm.

Another common pitfall that affects the development and implementation of interactive simulations is the conundrum of time compression. Strategic and operational level policy analysis models often rely on the conduct of simulated engagements to assess the applicability and effectiveness of a hypothetical course of action. In most cases, this requires the conduct of activities over a lengthy period of time both in reality and within the simulation. Unfortunately, the political, diplomatic, and military maneuverings that may spread over a course of weeks or months cannot be precisely replicated within the simulation. Time constraints on resources and available personnel make this impossible. Nevertheless, it is absolutely essential that these simulations be deep enough in time to allow completion of the action while ensuring the requisite human interaction and influence. Thus, the conundrum of interactive simulation emerges as the need to produce accurate representations of the target system while compressing weeks or months of activity into hours or days. One method frequently employed to meet this challenge is time-compressed, turn-based simulations.

Time-compressed turn-based simulations are used extensively to model policy-level activities as well as train operational personnel. The basic method of time compression involves the simple passage of some

¹¹⁰ Steve Bankes, *Exploratory Modeling for Policy Analysis*, RAND Report RP-211 (Santa Monica, Calif.: RAND, 1993). Reprinted from *Operations Research* 41, no. 3 (May-Jun 1993): 435.

length of time, whether days or weeks, between model phases or turns in the wargame. Such simulations are certainly able to cover large time blocks, yet they fail to adequately represent reality. For instance, a commander may order the movement of forces that require three days to deploy and engage. If the turn cycle is one week, these forces may have engaged the adversary and been victorious or simply been bypassed in the adversary's scheme of operations long before the commander has the opportunity to respond to changed conditions. While the rate of movement of military forces centuries ago may have made this board-game-like approach feasible, today's highly fluid battlefield environment demands a more realistic approach.

Representing the passage of time in order to simulate complete events and decision timelines requires the implementation of "smart" subordinate decision nodes. In reality, every action is the culmination of a series of activities, each of which has a distinct observe-orient-decide-act (OODA) loop¹¹¹. As time-compressed simulations are created to represent higher order activities, subordinate OODA loops are subsumed by set game rules or the discretionary decisions of the simulation controllers. As these subordinate loops grow in number, the distortion of reality and loss of fidelity become progressively greater. Eventually, the value of the simulation may be lost. In order to address this situation, developers have begun using expert systems to represent subordinate decision nodes.¹¹²

¹¹¹ John R. Boyd, "A Discourse on Winning and Losing," A collection of unpublished briefings and essays. Document No. M-U 43947 (Maxwell AFB, Alabama: Air University Library, August 1987) and David S. Fadok, "John Boyd and John Warden: Air Power's Quest for Strategic Paralysis" in *The Paths of Heaven: The Evolution of Airpower Theory*, ed. Phillip S. Meilinger (Maxwell AFB, Ala.: Air University Press, 1997), 366.

¹¹² The ideas presented in this discussion of time-compression issues resulted primarily from the author's interview with Mr. Matt Caffrey, Instructor, Air Command and Staff College and Chairman, Connections Conference, 3 February 1998.

The use of artificial intelligence techniques in modeling and simulation has increased as developer's understanding of these methods and the sophistication of computer science has grown. Modern computer science techniques have proven extremely valuable in understanding and explaining the complexities of these simulations and have narrowed the man-machine gap significantly.¹¹³ However, artificial intelligence is not a panacea. Successful integration of "knowledge-based modeling and simulation for complex problems requires an astute combination of expert system thinking and more traditional "hard" analysis: adopting heuristic approaches can be an excuse for fuzzy thinking and the failure to develop sound theories or straightforward algorithms."¹¹⁴ Yet, this integration makes possible the exploitation of "some of the richest ideas of the last thirty years—ideas arising from the social sciences on such issues as organizational behavior, bounded rationality, and the role of cognitive style in decisionmaking."¹¹⁵ Despite the obvious potential of using artificial intelligence in time-compressed simulations, its acceptance is slow in coming. For the present, most users of time-compressed simulations must accept the faults and limitations of discretionary constructs while attempting to maximize the value of these deficient simulations.

The implications of these various issues, challenges, and criticisms for the Airpower Application Framework are significant. Each of the models required to implement the AAF, from policy analysis to tactical execution, are affected by these concerns. As such, both developers and users of the construct must be aware of these concerns in order to retain the usefulness of the Framework as a decision aid. This is not a small challenge. The risks and problems involved are substantial, but the

¹¹³ Paul K. Davis, *Applying Artificial Intelligence Techniques to Strategic-Level Gaming and Simulation*, RAND Report N-2752-RC (Santa Monica, Calif.: RAND, March 1988), 21.

¹¹⁴ *Ibid.*

potential payoff in terms of increased effectiveness in meeting national policy objectives is equally high.

¹¹⁵ Ibid.

Chapter 6

Implications

The war with Japan has been [enacted] in the game room here by so many people and in so many different ways that nothing that happened during the war was a surprise—absolutely nothing except the kamikaze tactics towards the end of the war; we had not visualized those.

Admiral Chester W. Nimitz cited by Andrew Wilson in The Bomb and the Computer

In July 1995, Major General Link, then USAF/XO-RO, participated as the senior Air Force representative in Navy Global 95, a high-level wargame designed to assess joint capabilities in a two major-regional-contingency scenario. The results of this wargame and their implications for the Air Force, as described in General Link's thirteen page after-action report, can well be described as dismal.

Global 95 served as a vehicle to examine a number of strategic issues of concern to each service. The participants, which included senior Defense Department decision makers, gained insights into service capabilities during the game play that were likely to reinforce biases and ultimately impact future programs. Unfortunately for the Air Force, it was ill-prepared for this game in a number of ways. The results, which were quickly translated into a list of corrective action items assigned by the Chief of Staff of the Air Force, highlighted the need for significant enhancements in virtually all areas of the Air Force's modeling and simulation efforts. Major General Linhard, Director of Plans, placed the results of the exercise in these terms.

The Naval War College attempted to fairly and fully explore all the significant issues discovered through game play, but there were several discussions that may lead players to incorrect conclusions about Air Force competencies. Because of model limitations and incorrect assumptions on force deployment and employment capabilities, the relative roles, use and impact of AF forces were, in some cases, inaccurately represented.¹¹⁶

TACWAR was the model used during the wargame to represent Air Force capabilities. While adopted by the Joint Staff in 1988 to model land and air components at the theater level, it “falls short of realizing joint warfare synergies” and is, in fact, a “low resolution model that is not sophisticated enough to be used as a service-specific model.”¹¹⁷ General Link noted that “TACWAR models only that portion of theater airpower which the JFC apportions directly to the land battle. No effectiveness is returned for sorties devoted to strategic attack, deep interdiction, or offensive counter air.”¹¹⁸ Ultimately, General Link came to the conclusion that existing models did not “return plausible results from airpower employment” and that the “results of strategic attack, designed to render the enemy less capable of making war, or of achieving war aims, [were] not measured by any known model.”¹¹⁹ Beyond these model-centric concerns, General Link made this final comment.

These observations occur to me because of the obvious value of airpower based solutions to many of the dilemmas posed for national decision makers by the Global Wargame. At the critical point of NCA discussion over the risk vs. gain of beginning a counter-offensive, for example, I offered the option of simply continuing the offensive air campaign. The

¹¹⁶ Major General Robert E. Linhard, USAF, Director of Plans, DCS/P&O, staff summary sheet to General Robert R. Fogleman, CSAF, subject: GLOBAL 95 Issues, 16 August 1995.

¹¹⁷ Major Maggie Belknap, “The Force-On-Force Model: An Anachronism in the Information Age,” *Joint Forces Quarterly*, Spring 1997, 116.

¹¹⁸ Major General C.D. Link, “Navy Global 95 Lessons for Airpower,” 7 August 1995, 1. This trip report, while widely circulated, was officially passed to CSAF as an attachment to General Linhard's staff summary sheet. See note 2.

¹¹⁹ *Ibid.*, 1.

surprise and relief which greeted the suggestion reaffirmed both the value of modern airpower, and the extent to which it has been ignored in the contemporary national perspective. We have much work to do.¹²⁰

General Link's comments remain true today. The use of modeling and simulation is pervasive and its effects far-reaching. Consequently, the Air Force should make an effort to increase both the effectiveness of its M&S development efforts and the effectiveness of the models developed in those efforts.

The effective use of M&S in the strategic employment of airpower enhances the ability of the US to achieve national security objectives. Indeed, the use of models and simulations is now so prevalent in virtually all areas of airpower employment that it would be hard to image a scenario in which M&S doesn't play a role. There are several reasons for this. First, US forces, weapon systems, and operational concepts are changing *qualitatively*, which requires the development of new strategies and tactics to maximize operational performance.¹²¹ Second, fiscal constraints are forcing the Air Force to curtail exercises and routine training, while increasing the use of M&S to maintain proficiency. Third, shaping the force structure to meet projected threats requires careful analysis of a variety of future scenarios and development options. M&S provides a cost-effective method of conducting these analyses. Finally, dramatic changes are occurring throughout the international environment that ensure the Air Force will face diverse conditions across the spectrum of conflict. Here again, M&S techniques provide an important foundation for strategy and capability assessments that must precede employment decisions.

¹²⁰ Ibid., 4.

¹²¹ Paul K. Davis and Donald Blumenthal, *The Base of Sand Problem: A White Paper on the State of Military Combat Modeling*, RAND Report N-3148-OSD/DARPA (Santa Monica, CA: RAND, 1991), 3.

The fundamental impact of considering airpower strategies within the Airpower Application Framework is the potential of increasing airpower's effectiveness by the conscious linking of ends and means through a coercive mechanism. This is not a trivial task. The ability to link these essentials of policy requires a thorough understanding of the adversary's motivations, perceptions, and internal processes, as well as his economic, political, military, and social systems, infrastructure, and resources. Nonetheless, the Air Force should undertake the effort. Improved wargaming methods will enable a more efficient use of limited air resources in future conflicts.

In order to make the AAF decision aid a reality, the Air Force ought to pursue two courses of action. First, it must further its research into the nature of human behavior under the stresses of warfare. This involves more sophisticated and in-depth study of human reactions to the use of force at both the tactical and strategic levels. Further analysis of coercive mechanisms, targeting effects, airpower effectiveness, and historical precedents, such as that undertaken by Pape, Mueller, and Dupuy, is an important step. Secondly, the Air Force ought to pursue the application of exploratory modeling to strategic policy questions. This work is already well underway at RAND and needs increased attention by the Air Force and Defense Department modeling and simulation agencies.

The benefits of pursuing the development of the AAF decision aid are substantial. The capability to assess airpower strategies and their possible effectiveness in achieving national policy objectives provide the airpower strategist a powerful tool as he addresses these issues. By developing a substantive argument for a specific application of airpower, the strategist is better able to articulate the needs and requirements of airpower employment and its potential for success. This will be useful in justifying the necessary resources and the integration of the air effort with other instruments of national power. In addition, the more effective

use of airpower saves resources. Reducing the number of aircraft in a campaign, shortening the length of the conflict, or avoiding conflict altogether are all possible benefits of more effective employment strategies. Because the Airpower Application Framework has the capability to help develop more coherent strategies, its development and implementation ought to be pursued.

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